The design of archaeological surveys

Michael B. Schiffer, Alan P. Sullivan and Timothy C. Klinger

Introduction

Scarcely more than a decade ago at least one investigator felt compelled to defend the archaeological survey as a legitimate and productive research tool (Ruppé 1966; see also F. Plog 1968). Today, such apologia would be anachronistic, since surveys are the principal source of regional data (Johnson 1977; Struever 1971; Judge 1973; Gumerman 1971; Euler and Gumerman 1977; Dancey 1974; F. Plog 1974a; Schiffer and House 1975; Zubrow 1975; Dunnell and Dancey n.d.; Flannery 1976a; Reher 1977; Hester, Heizer and Graham 1975). For example, in the United States, where various laws mandate that regional archaeological studies occur in advance of land-modification projects and to facilitate long-term management of public resources, the survey is indispensable (Schiffer and Gumerman 1977a; McGimsey and Davis 1977). This 'conservation archaeology' has grown to the extent that large-scale surveys are taking place across the country and in some states literally dozens are in progress. Although much of the standard literature on survey design is obviously geared to areas, such as the American Southwest, where field conditions are optimal for intensive pedestrian tactics and probability sampling (Mueller 1974, 1975a; Redman 1974; F. Plog 1974a, 1974b), conservation archaeologists have experimented sufficiently under adverse conditions to make possible now a more general treatment of survey design (Goodyear, Raab and Klinger 1978; Schiffer and Gumerman 1977b). By drawing upon progress in conservation archaeology, we begin in this paper formulation of a flexible approach to archaeological survey, especially for study areas in excess of 50 km.^{2}.

The presentation commences with a treatment of several general issues in survey design. This is followed by a consideration of specific factors that influence decisions about survey techniques. Finally, brief mention is made of the process of acquiring information about survey factors in a multistage design, as needed for decision making.

Survey design is often viewed as the process for picking techniques that will provide an 'unbiased' or 'representative' sample of sites from a region (Binford 1964; Redman 1974). This view has led to the proliferation of probabilistic sampling designs and experiments to test their reliability. The general lessons of these studies seem clear, despite divergence on particulars: probabilistic sampling techniques (1) are not cost-effective discovery procedures under some field conditions (Aikens 1976: 8; Flannery 1976b: 135), (2) do not facilitate cost-effective discovery or population estimation of rare or highly clustered elements, particularly small elements (the misnamed 'Teotihuacan problem' – Mayer-Oakes and Nash 1967; Flannery 1976b: 135; True and Matson 1974: 89; compare Jelks 1975; Read 1977), but (3) do permit under favourable field conditions relatively good estimates to be made of nonclustered and abundant population elements. Clearly, many research and management problems require discovery of rare and clustered elements and estimation of their abundance in the population, sometimes where field conditions are poor. Achievement of these goals frequently necessitates the use of what Aikens (1976: 11) calls 'methodologically unlovely' techniques, such as purposive sampling and interviewing pot-hunters (see also Gunn, Ivey and Kelly 1977). Recent work is clarifying the important distinction between *discovery* of archaeological materials and *estimation* of regional parameters and this is leading in turn to a recognition of the complementarity of probabilistic and nonprobabilistic techniques in survey design. We hope to indicate the conditions under which each is appropriate.

It is important to emphasize that cost-effectiveness enters into survey design. Indeed, the prohibitive expense of completely surveying large areas provides the unassailable rationale for use of explicit sampling approaches (Mueller 1974; 1975a). Thus, in the absence of unlimited financial support, project planning inevitably involves the allocation of scarce resources. At present, decision making on the basis of cost-effectiveness is hampered by a dearth of comparable quantitative data for completed surveys. However, this situation is beginning to change with the keeping of detailed work records (e.g. Moratto 1976: 135) and provision in some reports of time-labour-cost figures for project activities. Labour estimates are listed or cited by Plog, Plog and Wait (1978), Schiffer and House (1977a: 45), Klinger and Medlin (1976, 1977) and Dincauze (1977). As more is learned about relative costs of various techniques, it will become possible to employ scientific management approaches (e.g. critical path analysis) for constructing and implementing survey designs (see Portnoy 1978).

Archaeological survey

In our view, *archaeological survey* is the application of a set of techniques for varying the discovery probabilities of archaeological materials in order to estimate parameters of the regional archaeological record. Following Dunnell and Dancey (n.d.: 9) the *regional archaeological record* is defined '. . . as a more or less continuous distribution of artefacts over the land surface with highly variable density characteristics'. High density areas, usually called 'sites', have traditionally been the focus of surveys. Recently, however, isolated artefacts and low density scatters have been shown to yield unique regional information (Dunnell and Dancey n.d.; Doelle 1976, 1977; Goodyear 1975, 1977; Thomas 1975; Rodgers 1974; Wait n.d.; Henderson 1977). As a result, discussions of survey design now include low density artefact distributions – or 'nonsites' (Thomas 1975) – as an important part of the regional archaeological record (Dunnell and Dancey n.d.; Dancey 1974; Plog, Plog and Wait 1978). Use of the term nonsite, however, is potentially misleading, especially in a management setting. We prefer to designate these phenomena 'low density artefact scatters' or 'sites of low obtrusiveness'.

Parameters are characteristics of the regional archaeological record (the *study area*). They may be general, such as the density or frequency of all sites or artefacts; or they can be very specific, such as the association of a site or artefact type with a particular microenvironment. The parameters of interest (*target parameters*) are determined by the problem(s) under investigation. Thus problem orientation is relevant to survey design only in so far as it affects the choice of target parameters. As a survey project progresses and early questions are answered, target parameters become more specific. For some management purposes, reliable parameter estimates will suffice; however, for other management and most research needs, they are just the starting point for making a variety of inferences about the past, such as population change and the development of subsistence-settlement systems.

Discovery probability is the likelihood that, given certain archaeological and environmental characteristics of the study area, *archaeological materials* (sites and artefacts) relevant for estimating target parameters will be encountered.

Survey design is the plan for efficiently acquiring the information needed to make sequences of decisions regarding deployment of appropriate techniques for discovery and parameter estimation (Schiffer 1978; Plog, Plog and Wait 1978). Techniques are selected within the framework of *recovery theory* (Sullivan 1978; Sullivan and Schiffer 1977). The principles of recovery theory specify how discovery probabilities vary with the archaeological and environmental characteristics of the study area and particular techniques. Recovery theory often makes use of sampling theory.

In much of the programmatic literature it is assumed that the estimation of a few very general parameters, such as total site density or abundance, is the principal goal of survey research. In practice, however, most problem orientations demand estimation of many target parameters, both general and specific. Because these varied parameters relate to archaeological materials that occur in differing frequencies and distributions in the study area, use of a single, multi-purpose survey technique may not be very efficient (compare Read 1977: 25–6). It is more realistic to view the regional archaeological record as being quite differentiated (Benson 1976; Morenon *et al.* 1976). In this way, techniques of discovery and estimation may be closely tailored to each target parameter. Thus multiple-survey strategies, incorporating several techniques, become necessary (Doelle 1977).

It is widely recognized that in order to select appropriate techniques, one needs to *know* the abundance and distribution of archaeological materials relevant to estimating target parameters (Peters 1970). Thus it is sometimes said that if such knowledge were available, the need for sampling would be obviated (e.g. Judge *et al.* 1975: 119). Resolution of this 'sampling paradox' (Mueller 1975b: 37) is readily accomplished by a careful definition of knowledge. Knowledge is not a presence-absence variable, but an approximation at any one time to a given parameter's value. Indeed, it may be measured by the precision and accuracy with which a parameter can be estimated (for discussions of precision, accuracy and other statistical concepts used in survey design, see Redman 1974: 6–7; Cowgill 1975: 265; Mueller 1975b: 37). Initially parameter estimates may be biased and imprecise; nevertheless, such estimates are better than none at all for making early decisions about survey techniques.

This view of knowledge provides a convincing justification for the use of multistage survey designs, as conservation archaeologists note (Vivian *et al.* 1977; McMillan *et al.* 1977; King 1975; King, Moratto and Leonard 1973). In such surveys, each stage improves the investigator's estimates of target parameters. Too often, stages of survey have been sequential without employing prior knowledge to influence decisions. Recovery theory shows how survey techniques are modified with changes in knowledge about target parameters and other characteristics of the study area.

In general the factors affecting discovery probabilities fall into two categories. The first consists of factors that the archaeologist cannot directly control: characteristics of the archaeological materials and environment of the study area. They include abundance, clustering, obtrusiveness, visibility and accessibility. Each factor can be discussed in terms of its effects on discovery probabilities and techniques that may be appropriate for varying those probabilities. The second category, dealing with factors totally under the control of the investigator, is represented by survey techniques and strategies, including probability sampling. The following treatment of factors, which serves as a vehicle for setting forth a number of recovery theory principles, basically follows this dichotomy. To make the presentation manageable in the allotted space, we take the modern pedestrian tactic (Mueller 1974) as a baseline technique. The pedestrian tactic involves the systematic inspection of the surface of a survey unit by observers spaced at regular intervals.

Abundance and clustering

Two important characteristics of archaeological materials are *abundance* and *clustering*. Abundance indicates the frequency or prevalence of a site or artefact type in the study area. It is often expressed as site or artefact density (number/unit area). In most study areas, there is likely to be a considerable range in the relative abundance of archaeological materials; some will be common while others are rare. Clustering is the degree to which archaeological materials are spatially aggregated. It can be measured by a variety of statistics, including Morisita's index of clustering (Rogge and Fuller 1977: 234), the coefficient of dispersion (Thomas 1975: 77), and the nearest-neighbour statistic (S. Plog 1976a: 145). Empirically, many site and artefact distributions tend slightly to cluster, and some are very clustered (see Rogge and Fuller 1977: 235–6; Thomas 1975: 75). Rare site types may be the most clustered of all, since they are often located on or near environmental features of limited and patchy distribution. Clustering, even of abundant site types, is also generally related to environmental variables.

Holding constant other factors, discovery probabilities of archaeological materials vary directly with abundance and inversely with the degree of clustering (Read 1975: 53). This principle, which does not apply to very large sites (S. Plog 1976a), has obvious implications for survey design. For abundant and nonclustered site and artefact types, even the crudest probability sampling technique is likely to furnish usable data for parameter estimation, given that other factors do not preclude use of probability sampling and pedestrian tactics. However, as clustering increases and abundance decreases, the sample size required for attaining parameter estimation at specified levels of precison and accuracy rises dramatically (Read 1975: 59; Asch 1975: 172–3). Thus, long before extreme values of rarity and clustering are reached, probability sampling ceases to be cost-effective, either for discovery or parameter estimation. For rare and/or clustered materials, greater gains can be obtained by employing purposive sampling techniques.

The use of purposive (i.e. biased) techniques in archaeological survey is tacitly discouraged in much of the literature, given the latter's emphasis on 'representativeness' (i.e. parameter estimation). However, even to consider parameter estimation for rare or very clustered materials in the face of vanishingly small discovery probabilities is folly. The first priority is discovery, and purposive techniques do offer the advantage of economically raising discovery probabilities to reasonable values. For example, in a study area of 2000 km.[2] containing the remains of eight small historic farmsteads, coverage using probability sampling would have to be unthinkably high merely to find one farmstead site. On the other hand, formulation of a predictive model on the basis of interview data, aerial photos, soil surveys and topographic maps of the study area would permit discovery of such sites with far less effort and might lead to a complete inventory. For rare and/or highly clustered materials, the clever use of purposive techniques offers the only cost-effective approach for discovery and perhaps parameter estimation.

Discovery of rare and clustered materials is accomplished by a variety of purposive techniques, many of which rely upon predictive models constructed from anthropological theory, information about the cultural materials of the study area and environmental variables. Predictive models commonly are based on probable relationships between environmental variables and the occurrence of site and artefact types (e.g. Gumerman 1971; Euler and Gumerman 1977; Casjens *et al.* 1977). Sites at which natural resources of limited distribution were procured can be found by inspecting areas where the resources occur. For example, outcrops of chippable stone, building materials, minerals and native metals often reveal evidence of procurement and preliminary processing activities (Roberts 1977: 37; Raab 1977: 5; House 1975a: 82). Hydrological data on springs, streams, rivers and drainage patterns (Roberts 1977: 37–8) furnish clues to the location of other rare or clustered types of material, such as villages, dams and canals. Unusual landforms or physiographic features, such as hilltops, rises, ridges or saddles, may prove to be areas where specialized activities took place, such as transportation, ritual, hunting or defence. Certain geological formations may contain caves, rock shelters or sinkholes where activities were performed. In addition, ethnographic, ethnohistoric and historic information may help to identify variables that conditioned site placement (Greenwood and White 1970). Some rare types will be known to local inhabitants, especially vandals and amateurs (House 1975b; Aikens 1976; Klinger 1976a; Hester 1977a). Remote sensing may also lead to discovery (Vogt 1974; Harp 1975; Lyons 1977; Lyons and Hitchcock 1977; Ebert and Hitchcock 1977; Cochran 1976). Also, disproportionate sampling of areas having a high material density would tend to increase the number of rare and clustered materials discovered (Epperson 1977; Donaldson 1977). And finally, as more is learned about the archaeology and environment of the study area, additional predictions can be made about materials that 'ought to be there' (House and Schiffer 1975: 41).

At present it is perhaps premature to consider the precision and accuracy of estimating parameters of rare and clustered materials discovered by purposive techniques. Nevertheless, one approach is to view some kinds of purposive sampling as *microstratification*. That is, the study area is divided up, on the basis of various criteria, into small units of space (microstrata) which have a high probability of containing certain site and artefact types. If these microstrata are searched systematically (perhaps even sampled probabilistically), credible parameter estimates may be possible (S. Perlman, pers. comm.). Where this approach is not practical, other solutions may yet be found. It is true that purposive techniques are highly biased (as they must be to raise discovery probabilities), but the magnitude of bias is sometimes easily learned and this allows appropriate corrections to be devised.

Obtrusiveness

Because most archaeological materials differ in size, constituents, surface morphology, heat retention and other physical, chemical and biological properties, they vary in the degree that they can be detected by various discovery techniques. *Obtrusiveness* is the probability that particular archaeological materials can be discovered by a specific technique. Obtrusiveness is related to the concept of 'threshold of archaeological visibility' (Deetz 1968: 285). However, the latter, which is defined without reference to technique, is of limited utility in survey design, since a site that cannot be detected by one technique may be discovered by another. Thus obtrusiveness, although dependent upon properties of archaeological materials, is also technique-specific.

Several examples show how obtrusiveness affects discovery probabilities. In general, pedestrian tactics disproportionately discover sites having a larger surface area, architectural remains and portions raised above the surrounding terrain (e.g. mounds and middens). More detailed inspection of survey units can reduce the bias to acceptable levels but will not eliminate it entirely. For soil phosphate analysis (Eidt 1977), the crucial variable is sufficient cultural deposition of phosphates. Thus techniques of soil testing discover sites depending on the activities carried out and the duration of occupation. And finally, small-diameter borers find buried sites having a high material density and detectable patterns of soil modification. It should be noted that very large sites, such as those containing Mississippian mounds, cannot fail to be found by even casual inspection techniques; yet other sites, such as those produced by a brief encampment of a hunter-gatherer task group, may defy the most advanced techniques and go undiscovered. Other relationships between obtrusiveness, techniques and discovery probabilities are introduced below.

Visibility

Within any study area the environment creates variability in the extent to which an observer can detect the presence of archaeological materials at or below a given place. This factor, which has a significant effect on discovery probabilities, is called *visibility* (Schiffer and Gumerman 1977c: 186–7). For example, in areas of recent alluvial deposition, the probability that a pedestrian surveyor will encounter a prehistoric site is near 0 (assuming low obtrusiveness). On the other hand, the discovery probability for a similar site located on a stabilized desert surface is close to 1. Discovery probabilities vary between these extremes in any study area because the environmental characteristics that affect visibility are not uniform. Additionally, seasonal changes in vegetation, precipitation and land-use may cause periodic fluctuations in visibility (Jackson 1976). Curiously, there are few thorough discussions about the effects of differential visibility in most survey reports (for exceptions, see Price *et al.* 1975: 79–87; Fehon and Viscito 1974; Klinger 1976a, 1977a).

A wide range of techniques is available for raising discovery probabilities, depending on the nature of the visibility problem. Thus it is important to stratify the study area into zones of differing visibility so that the most appropriate techniques can be applied in each. We now review various techniques and indicate the environmental situations where they appear to be useful.

Pedestrian tactics are most productive in places where the surface of the ground can be seen, such as cultivated fields and areas of sparse vegetation (deserts and some woodlands). Even in areas of generally good visibility, pedestrian tactics may have to be altered because of conditions that lower discovery probabilities. For example, crops, ploughing and rainfall patterns affect visibility in fields, and shrubs and trees obscure small sites and isolated artefacts. Visibility is also impaired by nearby vegetation, for the surveyor may miss materials not in the direct line of sight. Under these circumstances discovery probabilities can be increased by revisits under more favourable surface conditions (e.g. fields after ploughing and rainfall) or by more detailed inspection of survey units (King 1975: 12). Vegetation growing in disturbed soil may call attention to sites (Hole and Heizer 1973: 166).

Aerial remote sensing with ground-truth verification is proving to be useful, particularly for discovery of larger sites and those which affect vegetation patterns (see references above). It is well to note that remote sensing is actually a battery of diverse techniques, each sensitive to different properties of archaeological materials and the environment of the study area. Helicopters have been used to search for obtrusive sites in good visibility areas that are not covered by pedestrian tactics (Hester 1977b).

A very productive technique for overcoming visibility handicaps, especially in forested areas, is to seek disturbed places where the ground surface is exposed. Such places include 'dirt roads, trails, stream banks . . . previously cutover tracts' (Aikens 1976: 11), rodent burrows (Fox and Hester 1976: 75), cattle paths, garden plots, eroded surfaces, tree-falls, road cuts and areas of recent construction. Although utilization of existing exposures for site discovery makes parameter estimation very difficult, it can lead to efficient discovery of the range of commonly occurring, more obtrusive sites – assuming only moderate bias in exposed places (see Aikens 1976).

A variety of labour-intensive techniques of artificial exposure are being employed where the ground surface is obscured by leaf litter, pine duff, low vegetation or geological deposition (for comparisons of several techniques, see McManamon 1977; Casjens *et al.* 1977). Systematic use of garden rakes (Raab 1977) and shovel tests (Lovis 1976; Klinger 1977a; Claassen and Spears 1975; Plog, Weide and Stewart 1977; Williams 1976; Casjens *et al.* 1977; House and Ballenger 1976; McManamon 1977), has discovered sites near the ground surface. For example, in one Arkansas project, 30% of the sites were found by shovel testing (Klinger 1977c). If sites are buried by a non-cultural deposit of greater depth (*c.* 20 cm.–1 m.), power and manual augers, borers and coring tools may be useful (Kelly and Hester n.d.; Schoenwetter *et al.* 1973; Casjens *et al.* 1977). With the exceptions of shovel testing and power borers, none of these techniques is appropriate for very rocky soil. In very deep deposits, power equipment is mandatory for site discovery. For example, back-hoe trenching has revealed buried Archaic sites in the eastern US (Chapman 1976).

For existing and artificial exposures, discovery probabilities vary directly with (1) site area, (2) artefact density, (3) artefact size (features vs. lithic debitage), (4) surface area of exposure and (5) frequency of exposure. Techniques which expose only a small area, such as boring and coring, yield on the average few artefacts and often miss sites. They are perhaps most reliably used in conjunction with chemical soil testing (for discussions of the latter, see McManamon 1977; Eidt 1977; Baker 1975). Artificial exposure techniques may be supplemented by inspection of existing exposures, if they are present in sufficient numbers (e.g. House and Ballenger 1976). This is often necessary for increasing the sample of sites, since artificial exposure techniques require a substantial investment of labour for each discovered site (see data in Lovis 1976; Raab 1977). It should be noted that techniques of artificial exposure are theoretically compatible with probability sampling and reliable parameter estimation (Lovis 1976), and can thus aid in identifying and correcting biases that may affect exposures. Unfortunately, in neither case is it easy to calculate sample sizes. Further experiments, including the use of simulated data, will lead to improvements in parameter estimates employing existing and artificial exposures. After sites are found in exposed areas, additional testing generally is needed to determine site boundaries and artefact composition.

Experimentation with other techniques is occurring. For example, electronic aids such as proton magnetometry, side-scan radar, metal detectors and acoustic holography, are being tested under survey conditions. At present, however, we are unable to offer general advice as to their conditions of applicability. Obviously, techniques of underwater archaeology may be profitably employed in study areas having rivers, lakes and coastal waters.

Before a survey can be designed, information about vegetation, existing exposures, topography, geological history, hydrology and soils must be obtained on the study area so that strata based on visibility can be defined. The feasibility of using various techniques for increasing discovery probabilities should be determined for each stratum. Because such techniques are still in their infancy, part of the selected survey strategy is likely to be experimental. One thing does seem clear, however. Failure to consider concealed archaeological materials in many study areas will introduce large and uncorrectable biases into estimations of site diversity and other parameters, and will adversely affect reconstruction of occupational history.

Accessibility

Study areas also exhibit variability in the effort required to reach any particular place; these constraints on observer mobility are known as *accessibility* (House and Schiffer 1975: 4; Schiffer and Gumerman 1977c: 186–7). If accessibility problems are not solved, then in some parts of the study area discovery probabilities may approach 0.

More subtle effects of the accessibility factor include reduced efficiency of crews under humidity and temperature extremes and higher survey costs for areas with rugged terrain and few roads. Five major variables influence accessibility: climate, the biotic environment, terrain, extent of roads and land-holding patterns.

Climate affects accessibility in several ways. Precipitation not only prevents field-work directly, but muddied roads and snow on the ground preclude it for many days or weeks afterwards. Early identification of precipitation patterns is a must so that sufficient time is allotted for field-work. Although surveys are conducted during the summer in the Sonoran and Mohave deserts, extreme conditions should be avoided, for they are bound to (1) reduce discovery probabilities, (2) increase costs because of the shorter effective working day and (3) may lower crew morale. It is desirable to concentrate field-work during more favourable seasons.

The biotic environment of the study area also influences accessibility. Certain kinds of plant communities, such as dense forest and jungle, drastically lower crew mobility. Machetes and other techniques for partial denudation can be helpful, but no speedy, inexpensive solution is in sight. The possible presence of dangerous and annoying animals and plants inevitably causes greater wariness on the part of crew members and may lead to costly and unpleasant preventive (or remedial) actions.

In areas of rugged terrain costly methods of transportation may be necessary for placing crews in survey units (and rescuing them later). If dirt roads are present, then four-wheel drive vehicles are advisable. Mountain climbing equipment and helicopters are sometimes employed. And exploration of caves requires specialized gear and expertise (McEachern and Grady 1977). Rugged terrain may affect the shape, size or orientation of survey units, depending on the extent of roads and the ability of the crew to camp out. For example, if crews do not camp, then it makes sense to select units that are small enough to be completely surveyed in one day (see Plog, Plog and Wait 1978). However, if roads exist, larger survey units may be placed in close proximity to them (see also Gerstle, Kelly and Assad 1977). It should be clear that these sorts of decisions can be made only with detailed knowledge of the study area.

The last major variable is the pattern of land holding. In parts of the western United States, public land frequently comprises 100% of a study area. In the east, however, most of the land is privately owned, often in small parcels; thus the landowner or tenant may refuse access. When this occurs, despite tact and persistence on the part of the crew, options for site discovery are limited to remote sensing, predictive models, existing records and interviews. The mere act of obtaining permission to survey and collect on many small holdings can take an appreciable amount of time, and several visits may be needed. Patterns of land holding can of course affect survey unit size, shape and placement (see Schiffer and House 1977b; Richner and Lee 1977).

The development of viable approaches for coping with accessibility problems is not very far advanced. Regrettably, we are unable to offer specific recommendations and can only underscore the importance of learning about accessibility as soon as possible. Generally it is not too difficult to stratify a study area into actual or potential accessibility zones. Remotely sensed data, meteorological data, topographic maps and administrative records of land owners provide the requisite information.

Quite clearly, visibility and accessibility have far-reaching effects on the results of archaeological survey. We even suspect that known site densities and the detail with which the prehistory is thought to be understood in different parts of North America, for example, are correlated with differences in visibility and accessibility (and obtrusiveness). Fortunately, conservation archaeologists are being forced to work where field conditions are poor. This is leading to experiments with new techniques and to a greater appreciation of how these factors affect survey design. For example, if most of a study area is highly visible and accessible, then pedestrian tactics and probability sampling techniques can be applied profitably. On the other hand, if zones of low visibility and accessibility predominate, then pedestrian tactics will usually be fruitless, although probability sampling may have a role to play in selecting spots to apply techniques of artificial exposure and other specialized approaches. Most study areas have a mix of accessibility and visibility factors that lie between these extremes. Selection of an appropriate suite of techniques therefore places considerable demands upon the investigator and requires thorough familiarity with the study area.

Decisions relating to probability sampling

The following discussions on probability sampling are based on several assumptions: (1) factors of visibility and accessibility are known and do not make the use of pedestrian tactics totally unfeasible, (2) preliminary estimates of abundance, clustering and obtrusiveness are available for relevant archaeological materials and (3) for financial reasons, only a small fraction of the study area can be inspected.

Although a handful of experiments have been carried out using various probability sampling designs on archaeological data from complete surveys, it is difficult to extract general principles from these studies, not already articulated by statisticians, that are useful in survey design. These studies suffer from insufficient repetitions and probable sampling error (e.g. Chenhall 1975; Judge *et al.* 1975; Mueller 1974; True and Matson 1974; exceptions are DeBloois 1975; S. Plog 1976a; Fuller, Rogge and Gregonis 1976), statistical errors (e.g. Chenhall 1975 – see Cowgill 1975: 268), differences in parameters of test populations (DeBloois 1975: 34; Thomas 1978) and in the statistics deemed appropriate for test comparisons (Matson and Lipe 1975: 137–8; DeBloois 1975: 11–12; Judge *et al.* 1975: 106–15; S. Plog 1976a: 140–1; S. Plog 1978; Mueller 1978). Differences of opinion also exist as to what constitutes cluster sampling in archaeology and its implications (e.g. Plog, Plog and Wait 1978; Read 1975; Thomas 1975; Mueller 1975b; Peters 1970). Despite contradictory pronouncements on many points, it is generally agreed that characteristics of the archaeological materials, target parameters, logistics and other variables influence the major sampling decisions, including the required level of precision and accuracy of parameter estimation.

Unit size

Holding constant unit shape (quadrat), sampling scheme (simple random) and total surveyed area, several statements can be made about the advantages of large (*c.* 1·5 km.^{2}) and small (*c.* 0·1 km.^{2}) sample units. Costs are lower for locating in the field and moving crews between larger units (Read 1975: 53, 1977: 21; F. Plog n.d.a; Redman 1974: 19). Larger units are more likely to disclose clustered element distributions (DeBloois 1975: 15), and to reveal patterns of association and intersite relationships (F. Plog n.d.a). *Edge effects*, which result from ambiguity of site inclusion on unit edges, are reduced for larger units (those having a lower perimeter/area ratio) (Read 1975: 53; Redman 1974: 19; Plog and Wood 1977: 54; Plog, Plog and Wait 1978), although this may be a detriment if a higher priority is placed on site discovery than on parameter estimation. And finally, larger units have greater site counts, reducing the skewness in the sample distribution (Redman 1974: 19; Rogge and Fuller 1977: 235–6). On the other hand, smaller units, because there are more of them, yield improved parameter estimates (S. Plog 1976a: 151: Redman 1974: 19; Read 1975: 53; True and Matson 1974: 89; Plog, Plog and Wait 1978), particularly if relevant materials are abundant overall (Matson and Lipe 1975: 132–3) and if there is a lower density of materials near edges of the study area (adapted from DeBloois 1975: 107–17). Natural units may be employed, even of varying size (and shape). For example, on islands (Glassow 1977a: 126–30) and lake margins (Fuller, Rogge and Gregonis 1976) small drainages furnish a convenient sampling unit.

There is no single best unit size (Thomas 1978). The choice is influenced by many considerations, including logistics, funding, target parameters and the distributions of relevant archaeological materials (see Judge *et al.* 1975: 87). For example, if a researcher has abundant funds and an interest primarily in inter-site spatial analysis, large units might be employed (other factors permitting). If funds are scarce and the goal is estimation of overall site density, units of intermediate size may be chosen, perhaps using the formula provided by Read (1975: 58). Because of multiple target parameters and other factors, however, decisions are seldom that simple. The selection of unit size, like other decisions, usually is a compromise based upon project-specific weighting of various factors (Schiffer and House 1977b). Indeed, in some cases it is desirable to use a mix of unit sizes (see discussion under *intensity*).

Unit shape

A few archaeological studies have treated the effects of sample unit shape (Plog, Plog and Wait 1978), and their results apparently are contradictory. The problem is that, as with unit size, many considerations affect the decision. Thus transects may be optimal for one study, while quadrats are indispensable for another. Holding constant unit area, sampling scheme and total surveyed area, some effects of quadrats and transects may be identified. Quadrats, it is claimed, provide better parameter estimates in stratified schemes (Bettinger 1977: 13–14; Judge *et al.* 1975: 110). However, we suggest that in these cases the gain in precision results not from unit shape, but unit or sample size. Unfortunately, past experiments have not clearly distinguished between these effects. Quadrats may disclose information on site associations and distributional patterns (Redman 1974: 20; Matson and Lipe 1975: 132). Finally, quadrats with their less pronounced edge effects ought to provide better parameter estimates. However, because transects, particularly narrow ones, have large edge effects they can be used to advantage. Although transects overrepresent more obtrusive sites (given the tendency to include, rather than exclude, sites on unit edges), the overall increase in site discovery (per unit area surveyed) is appreciable (Plog, Plog and Wait 1978). This property makes transects very attractive (since such systematic biases can be corrected), especially for early project stages when the investigator is primarily seeking information on the range of material types, relative density and degree of clustering. Transects are often easy to delimit and cover in the field (e.g. Judge *et al.* 1975: 88; Klinger 1976a, 1977b), although it may be difficult to keep a perfectly straight course (S. Plog 1976a: 140). Laid across the grain of environmental zones, transects apparently furnish good estimates of site variability and general population parameters (Judge *et al.* 1975: 88; see also S. Plog 1976a: 151–2). In addition, transects are ideal units for simultaneously making a variety of ecological observations (Goodyear 1975; Reher 1977). Although transects seem superior for many applications, a number of project-specific considerations, and the priorities placed on each, will dictate the choice of unit shape.

Sampling scheme

Sampling scheme is the procedure by which sample units are selected. Although many investigators have discussed sampling schemes and offered advice (e.g. Ragir 1967; Redman 1974; DeBloois 1975; Read 1977; Plog, Plog and Wait 1978; Hester, Heizer and Graham 1975), there are few reliable generalizations. The reason is that of all the factors that affect discovery and parameter estimation, sampling scheme may be the least important (compare S. Plog 1976a: 157). Thus, in many experimental studies, sampling scheme influences are masked by more significant variables. Nevertheless, because simple random samples create patchy coverage, and because archaeological materials often are clustered, it is desirable to employ a technique that increases the spatial dispersion of sample units. Redman (1974: 11), Glassow (1968), and DeBloois (1975: 8–11) present several appropriate techniques. Systematic or interval schemes should of course be avoided when periodic site distributions are expected. Even within probability sampling schemes, accessibility may affect unit placement (DeBloois 1975: 12; Schiffer and House 1977b; Hanson n.d.).

Stratification

Many investigators advocate that a study area be divided into subpopulations or strata, each of which is sampled independently (Binford 1964; Bettinger 1977). If strata are relatively homogeneous, then a given level of precision can be attained with a smaller sample size. We have already treated stratification on the basis of visibility and accessibility criteria, and microstratification. Several studies also suggest that strata defined by ecofacts (biotic communities or landform types) may improve parameter estimates (Matson and Lipe 1975: 143; DeBloois 1975: 12; Judge *et al.* 1975; Plog, Plog and Wait 1978).

Sample size and fraction

In much of the literature confusion exists between sample size and sample fraction. As a result, most advice on this matter is spurious. In so far as parameter estimation is concerned, 'unless the sampling fraction is more than 20% of the total population, the *proportion* of the population . . . is of negligible importance' (Cowgill 1975: 263, his emphasis). Thus, most discussions of 1% or 10% samples are irrelevant, for it is the 'actual number of independent cases [survey units]' that affects the results (Cowgill 1975: 263). Sample size depends on the variability in the population (especially abundance and clustering), required degree of precision, available resources (Cowgill 1975: 263; Binford 1964: 429) and sampling technique (Read 1975: 51). One rule of thumb, in accordance with the Central Limit Theorem, is to use more than thirty sample units; otherwise, depending on the skewness of the archaeological distributions, formulas for parameter estimation may be inapplicable, and this defeats the purpose of using probability sampling (Rogge and Fuller 1977: 237; compare Thomas 1975: 68).

Intensity

Among the factors that the archaeologist can control, *intensity* has the most profound effect on discovery probabilities and parameter estimation, as Plog, Plog and Wait (1978) have convincingly shown. Intensity is the amount of effort devoted to inspecting surveyed areas (Plog, Plog and Wait 1978; Schiffer and Gumerman 1977c: 184–5; House and Schiffer 1975: 40–1). It is measured directly by the spacing interval between crew members using the pedestrian tactic (Doelle 1977: 204; Cinadr 1976: 21; Bettinger 1977: 16), and indirectly by the number of person-days per unit area inspected (Schiffer and House 1977a: 45; Schiffer and Gumerman 1977c: 186). The latter index of intensity obscures variability resulting from differential accessibility, recording and collecting time, bad weather, transportation time, equipment failure etc. In addition, the crew-spacing measure is easier to relate to discovery probabilities for materials of varying obtrusiveness. Because intensity directly reflects the amount of labour required for field-work, it is highly correlated with total survey cost per unit area.

If all sites in a study area are *very* obtrusive, a low intensity survey, perhaps at 100 m. intervals, would encounter nearly all sites. On the other hand, if there are mostly small sites and isolated artefacts, inspection would be needed at intervals of no more than a few metres in order to find the majority of surface artefacts (Doelle 1977; Lovis 1976). Unfortunately, study areas usually include archaeological materials covering a range of obtrusiveness. Since it is seldom practical to conduct an entire survey at 2 m. spacing – thus ensuring high discovery probabilities for all phenomena within survey units – compromises in intensity are in order.

Commonly, intermediate spacing intervals of 10–75 m. are employed. It is true that isolated artefacts can be found using such intervals; nevertheless, parameter estimates for materials of low obtrusiveness may be sacrificed because it is difficult to standardize the sample size. Doelle (1977) suggests a more viable compromise, the 'multiple-survey strategy' (see also Flannery 1976c: 159–60). He argues that once information is available on the size range of materials in the study area, several unit sizes and levels of intensity may be combined for estimating different parameters. For example, coverage of large units at wide intervals furnishes estimates of highly obtrusive materials, while a number of small units surveyed at close intervals yields estimates for less obtrusive materials (see also Morenon *et al.* 1976). Experiments using the multiple-survey strategy are needed to determine its cost effectiveness.

Intensity, like other factors that the archaeologist varies, is responsive to many considerations, including target parameters, range of obtrusiveness, available support and, of course, visibility and accessibility. Abstract prescriptions for intensity, made without reference to project-specific information, should be discounted.

Additional considerations

For lack of space we treat in abbreviated fashion other survey design considerations, some of which appreciably affect discovery probabilities and parameter estimation.

Field workers

Field workers vary in survey skills and crews have different group dynamics that affect the quality of work that is done (Plog, Plog and Wait 1978). In particular, archaeological materials of varying obtrusiveness may be discovered differentially. Reduction of such effects is facilitated by three measures: (1) provide workers with a pre-survey orientation to the study area, perhaps in an early reconnaissance stage, to familiarize them with artefact and site variability and field conditions, (2) monitor the accuracy of recovery by resurveying selected areas with another crew and (3) randomize errors by shifting people among crews (Dunnell and Dancey n.d.; Daniels 1972).

Site definition

The occurrences of artefacts in a study area customarily are thought to cluster in natural observation units called 'sites'. Recent interest in small sites and limited activity locations (e.g. F. Plog 1974a; Moseley and Mackey 1972; Dillehay 1973; Talmage and Chesler 1977), and the demonstration that low density scatters contain important information about past human behaviour, reveal difficulties in operationalizing the site concept (see also Klinger 1976b; Thomas 1975; Schoenwetter *et al.* 1973). Experiments with completely arbitrary criteria for site definition have not been notably successful, as several investigators point out (Chapman *et al.* 1977: 174; Dunnell and Dancey n.d.; Plog, Plog and Wait 1978). They also conclude that the decision as to what empirical manifestation constitutes a site often must be made in the field using multiple criteria. Clearly, crews need to have considerable expertise and the ability to account for their decisions *quantitatively*. For other issues relating to site definition, see Schiffer and Gumerman (1977c: 183–4), Morenon *et al.* (1976), Plog, Plog and Wait (1978), Dunnell and Dancey (n.d.) and Sullivan and Schiffer (1977).

Recording procedures

Another, sometimes substantial, source of variability derives from recording procedures. Standardized recording forms, usually geared to computer analysis, are becoming common. Klinger (1977a) has used optical scanning techniques for direct computer input of site data from field records. Investigators now often publish in reports an example of their recording forms (e.g. House and Schiffer 1975: 43–4; Gerstle, Kelly and Assad

1977; Moratto 1976: 140–5; Price *et al.* 1975: 81; Biella and Chapman 1977; Klinger 1976a). Aerial photos are becoming all but indispensable for plotting site locations. Plog, Plog and Wait (1978) provide a general discussion of recording procedures.

Surface collections

Several archaeological agencies and institutions have recently adopted 'no-collection policies' for surveys. While the conservation ethic underlying that approach is commendable, it may have undesirable effects on scientific research. It is true that *in situ* artefact analysis reduces transport, processing, analysis and curatorial costs, but it also increases preparation, training and field-work costs and may foreclose options for some later analyses. Naturally, it is desirable to design a survey so that relevant 'data can be collected as information and do not have to be collected as artefacts' (Chapman *et al.* 1977: 182). However, logistics, weather, amount of previous work in the area, target parameters and other project-specific considerations should determine the need or lack of need for artefact collecting – not administrative policies. For further discussions of surface collection, see Schiffer and Gumerman (1977c: 189–90), Schiffer (1975: 6), Morenon *et al.* (1976), Dunnell and Dancey (n.d.), Enloe (1977), Chapman *et al.* (1977: 182–99) and Plog, Plog and Wait (1978). Collecting techniques are described by Binford (1964: 436), Redman (1974: 4–5), House and Schiffer (1975: 50–2), Hester, Heizer and Graham (1975: 15–16, 20–1), Price *et al.* (1976: 84–7), Chomko (1974), Talmage and Chesler (1977) and Plog, Plog and Wait (1978). Different collecting conditions also affect the recovered artefact inventory (Fish 1976: 13; Williams 1976; Talmage and Chesler 1977: 8; Jackson 1976: 37–8; Nunley and Hester 1975: 4–5).

The proper use of surface data, observed or collected, requires an understanding of the nature and extent of previous collecting, noncultural disturbance, and the complex relationships between surface and subsurface materials (see Talmage and Chesler 1977; Schiffer 1976, 1977). Several studies have discerned tentative regularities in collector behaviour (F. Plog n.d.b; see citations in Schiffer and Gumerman 1977c and Schiffer 1977). Other cultural formation processes, such as ploughing, are becoming better known (see citations in Talmage and Chesler 1977; Plog, Plog and Wait 1978; Schiffer and Gumerman 1977b). Environmental disturbance processes are reviewed by Wood and Johnson (1978). The conditions under which surface-material distributions are isomorphic with subsurface distributions are poorly understood, and fully general claims about such relationships should be dismissed. Preliminary investigations include those by Binford *et al.* (1970), Redman and Watson (1970), Schiffer and Rathje (1973), Reid, Schiffer and Neff (1975), Glassow (1977b), Tolstoy and Fish (1975) and Synenki (1977). Baker (1978) has shown that, for a variety of reasons, surface materials overrepresent large items. The 'size effect' also operates on collections made from the surface (see Perlman 1977).

Testing

Because knowledge of the regularities of formation processes is presently imperfect, it is difficult to predict in detail the nature and content of subsurface materials from surface inspection. As a result, it is common during late survey stages of conservation archaeology projects to conduct limited test excavations, particularly for the purpose of identifying research potential (Schiffer and Gumerman 1977c: 190). Glassow (1977b: 11–13) lists several important kinds of information obtainable through testing: species and densities of faunal remains, types and densities of artefacts, types and densities of certain industrial and culinary debris, presence and extent of burials, occurrence of specialized deposits with dense remains, differentiation of strata and lenses, discreteness of occupational episodes, extent of human and animal disturbance, conditions of artefact, ecofact, feature and surface preservation, and variability in the soil matrix. To this we add variability in site depth and boundaries (e.g. Schoenwetter *et al.* 1973). Testing also facilitates cost estimation for full-scale excavations (see Skinner and Gallagher 1974). Since it is seldom possible to test thoroughly all discovered sites, testing activities should be structured in part to permit evaluation of the principles used to infer the contents of untested sites from surface observation (see House 1975c; Bruseth *et al.* 1977).

Acquisition of information for survey design

Throughout this presentation we have emphasized the kinds of knowledge needed for making decisions about survey techniques that will lead to the most cost-effective survey design; that is, one providing the greatest precision and accuracy of parameter estimates for each dollar spent. To help avoid unpleasant surprises in the field and later disappointment with results, we recommend a three-stage survey, each stage of which strives to secure the information needed for designing subsequent stages (see S. Plog 1976b). Our presentation is necessarily abstract, as it must be without a study area and target parameters. Thus, our outline should not be confused with a survey design: it is merely a heuristic device for elucidating some relationships between information acquisition and decision-making in the process of survey design (see also Schiffer 1978; Plog, Plog and Wait 1978; Dunnell and Dancey n.d.).

Stage 1 – background studies

In the first stage the investigator identifies and assesses the utility of various sources of information pertaining to the cultural materials and environment of the study area, and becomes familiar with field conditions. One begins by ferreting out published and unpublished reports of previous archaeological and historic research and establishing contacts with persons in archaeology and other fields who are also interested in the study area. Sources on nearby areas are consulted, particularly if little or no earlier work has been carried out in the study area.

Very often, despite a lack of professional research, a great deal may be known already. Thus one peruses the files of local and regional museums, state or provincial archaeologists, avocational societies, historical societies and commissions, registers of historic places, local and regional libraries, administrative units and churches (see Barber and Casjens 1977; Roberts 1977: 33). It is helpful to identify local informants and amateurs and to determine the availability and information potential of any artefact collections

(Peebles *et al.* 1976; Fish n.d.; House 1975b). Needless to say, making friendly contacts is bound to increase the prospects of future co-operation and enhance the image of professional archaeologists (Barber and Casjens 1977). The availability of ethnohistoric and ethnographic data from and adjacent to the study area is also learned. While identifying and assessing each source of information one calculates, however coarsely, the time and effort required to collect and analyse potentially relevant data.

Information about the study area is also pursued in environmental science fields. In particular, geological, soils, hydrological, meteorological and biological studies are sought, as well as interested individuals. If the environment and natural history are poorly known, the investigator should identify persons in relevant fields who are willing to take part in inter-disciplinary projects. Sources of remotely sensed data and maps are investigated; the military and governmental mapping services can be of assistance. Aerial photos taken at different times may be found, permitting observation of trends in cultural and environmental processes.

As a final element in Stage 1 the investigator should conduct an inspection of the study area in order to begin gauging visibility and accessibility problems firsthand, including the presence of existing exposures and time factors for securing permissions to survey. In addition, one can visit some known sites and locate places to live, eat and refuel.

At the end of Stage 1 the investigator possesses ***preliminary*** knowledge on the (1) occupational history of the study area, (2) general range of archaeological materials, (3) sources of archaeological, historical, ethnohistoric and ethnographic data that may warrant intensive study, (4) local experts on the study area in archaeology and other fields, (5) outstanding research problems, (6) inter-disciplinary studies that need to be done, (7) preliminary visibility and accessibility strata, (8) fieldwork logistics and (9) general target parameters. On the basis of this information, it is possible to formulate a *provisional* research design and initial cost estimate for the remainder of the project and a detailed workplan for Stage 2.

Stage 2 – reconnaissance

The principal purposes of Stage 2 are to secure initial field-based estimates of archaeological characteristics and to determine the most cost-effective survey techniques (Grady 1975). If conditions of visibility and accessibility permit, one may systematically employ a technique that maximizes discovery probabilities for a wide range of materials, preferably one whose biases are well known and easily corrected. A productive strategy is the placement of very narrow, long transects across environmental zones (Klinger 1976a, 1977a). Although biased towards obtrusive sites, data from such transects, or genuine random walk coverage, can be readily corrected to permit (1) expansion of the range of site and artefact types and variability in obtrusiveness, (2) delineation of the frequency distribution and degree of clustering of common material types, (3) specification of differential material density among environmental zones, (4) pilot-testing of discovery and transportation techniques in strata of poor visibility and accessibility and (5) concurrent study of environmental variability (for testing stratification criteria and gathering relevant ecofacts).

During reconnaissance, artefact collections are studied, if available, or are acquired from the field so that recording and analysis forms can be devised. Forms are tested *in the field*, refined and retested. The accuracy in plotting of site locations is evaluated. The range of destructive processes presently affecting archaeological materials is observed and documented.

More intensive study of existing cultural information, such as archives, is begun in Stage 2. Collaboration with historic site archaeologists (see South 1977a, 1977b), ethnohistorians and ethnographers may commence.

At the close of Stage 2 the investigator should have at hand (1) provisional identification of specific target parameters, (2) fairly precise estimates of general target parameters, (3) survey strata based on visibility, accessibility and perhaps ecofactual criteria, (4) microstrata for purposive survey, (5) an arsenal of survey techniques appropriate for each stratum, (6) recording and analysis forms and (7) informed cost estimates for survey activities. Now, and only now, is it possible to design a detailed workplan for the intensive survey.

Stage 3 – intensive survey

The purposes of Stage 3 are to increase to acceptable levels of precision and accuracy estimates of specific target parameters so that research (and management) questions can be answered confidently and to furnish information that may be needed for subsequent excavations. Owing to the many study area-specific factors that influence survey design, a great variety of activities may comprise Stage 3. Indeed, Stage 3 would probably be divided into discrete substages.

The core of Stage 3 often is a probabilistic sample set within a framework of stratification based on biotic, topographic, visibility and accessibility zones. Depending on the variability in archaeological materials, range of obtrusiveness, and accessibility and visibility factors, a multiple-survey strategy may be adopted. Naturally the size, shape, number and methods of placement of sample units is chosen on the basis of project-specific considerations. In some cases, units will vary among the strata, as will survey techniques (e.g. Klinger 1977a). There is no scientific reason for slavishly adhering to consistency if, as a result, parameter estimation suffers. Thus it is entirely conceivable that pedestrian tactics, applied probabilistically in a multiple-survey strategy, are carried out in one part of the study area, while artificial exposure techniques are employed opportunistically in other parts.

On the basis of environmental, archaeological, ethnohistorical, historic and ethnographic data, microstrata will be delineated and rare and clustered site and artefact types, especially unobtrusive ones, will be sought. In addition, areas of high material density may be investigated at a higher rate in order to increase the sample of relevant site and artefact types (see Judge 1973; Donaldson 1975).

Throughout Stage 3, environmental studies may continue, as well as research using nonarchaeological sources of data and investigations of disturbance processes. It is during Stage 3 that testing is conducted. Indeed, G. Hanson (pers. comm.) suggests the desirability of carrying out an intensive testing stage.

Conclusion

Archaeological survey is a complex set of activities which function to increase the precision and accuracy with which parameters of the regional archaeological record are estimated. Because the many factors that influence survey decisions vary independently, it is impossible to set forth a specific design or even specific activities that can be employed cost-effectively in all study areas. It is possible, however, to consider each factor theoretically and assess its effect on the selection of survey techniques. Thus survey design is best viewed as the dynamic process of using increasingly precise knowledge about the archaeological and environmental characteristics of the study area and the principles of recovery theory to make decisions about future survey activities and techniques.

Our view of survey design will not be congenial to investigators who rely on cookbook approaches. We have not supplied magic numbers or formulae, for there are none. We have emphasized that survey design is the process of making usually difficult decisions. There is no substitute for thoughtful consideration of theoretical factors and relevant characteristics of the study area. Clearly, as the principles of recovery theory expand and more refined data accumulate on the cost-effectiveness of survey techniques, we will be in a better position to formulate elegant and productive survey designs.

Acknowledgements

This synthesis owes a great deal to the many people who freely supplied ideas, furnished manuscripts and leads to sources and critically reviewed earlier drafts. For assorted aid and comfort we thank: R. L. Bettinger, F. J. Broilo, B. R. Butler, L. Casjens, J. S. Dean, B. Donaldson, R. C. Dunnell, F. J. Findlow, P. Fish, M. A. Glassow, M. Grady, D. F. Green, G. T. Hanson, J. A. Hanson, M. Henderson, J. J. Hester, T. R. Hester, D. Ives, A. J. Lindsay, Jr., W. D. Lipe, W. Lovis, R. McGuire, F. McManamon, R. McSwain, M. J. Moratto, C. Peebles, F. Plog, S. Plog, D. E. Weaver, D. R. Wilcox, R. Wilson. All errors and inconsistencies that remain can be attributed to the stubbornness of the senior author.

10.xii.1977

Department of Anthropology
University of Arizona
and
Arkansas Archeological Survey
University of Arkansas, Fayetteville

References

Aikens, C. M. 1976. *Some archeological concerns of the Bureau of Land Management in Oregon: observations and recommendations.* Manuscript, Department of Anthropology, University of Oregon.

Asch, D. L. 1975. On sample size problems and the uses of nonprobabilistic sampling. In *Sampling in Archaeology*, pp. 170–91 (ed. J. W. Mueller). Tucson: University of Arizona Press.

Baker, C. M. 1975. The Arkansas Eastman Archeological Project. *Arkansas Archeological Survey, Research Report* 6.

Baker, C. M. 1978. The size effect: an explanation of variability in surface artifact assemblage content. In Contributions to archaeological method and theory (ed. M. B. Schiffer). *American Antiquity*. 43.

Barber, R. and Casjens, L. 1977. Interviews, library research, and locating known sites. Paper read at the Northeastern Anthropological Association Meeting. Providence, Rhode Island.

Benson, C. L. 1976. Assessing the adequacy of a regional sampling design: Cedar Mesa, Utah. Paper read at the 41st Annual Meeting of the Society for American Archaeology, St Louis.

Bettinger, R. L. 1977. The surface archaeology of the Long Valley caldera, Mono County, California. *University of California, Riverside, Archaeological Research Unit, Monographs* 1.

Biella, J. V. and Chapman, R. C. (eds). 1977. *Archeological investigations in Cochiti Reservoir, New Mexico. Volume 1: A survey of regional variability*. Albuquerque, New Mexico: Office of contract archaeology, University of New Mexico.

Binford, L. R. 1964. A consideration of archaeological research design. *American Antiquity*. 29:425–441.

Binford, L. R., Binford, S. R., Whallon, R. and Hardin, M. A. 1970. Archaeology at Hatchery West. *Society for American Archaeology, Memoirs* 24.

Bruseth, J. E., Bagot, J. T., Banks, K. M. and McKinley, M. A. 1977. Archaeological research at Lake Fork Reservoir: site inventory and assessment. *Southern Methodist University, Archaeology Research Program, Research Reports* 87.

Casjens, L., Roberts, M., Bawden, C. and Talmage, V. 1977. Field methods in New England cultural resource management. Paper read at the Northeastern Anthropological Association Meeting. Providence, Rhode Island.

Chapman, J. 1976. Early Archaic site location and excavation in the Little Tennessee River valley: backhoes and trowels. *Southeastern Archaeological Conference Bulletin*. 19:80–90.

Chapman, R. C., Enloe, J. G., Abbink, E. K., Stein, J. R. and Warren, A. H. 1977. Survey of Cochiti Reservoir: methodology. In Biella and Chapman, 1977.

Chenhall, R. G. 1975. A rationale for archaeological sampling. In *Sampling in archaeology*, pp. 3–25 (ed. J. W. Mueller). Tucson: University of Arizona Press.

Chomko, S. 1974. A survey technique for delimiting activity areas within a site. *Missouri Archaeological Society, Newsletter*. 278:1–5.

Cinadr, T. J. 1976. Mount Bennett Hills Planning Unit: Analysis of archaeological resources. *Idaho State University, Museum of Natural History, Archaeological Reports* 6.

Claassen, C. P. and Spears, C. 1975. An assessment of site surveying, shovel testing and augering. In Baker 1975, pp. 123–7.

Cochran, R. J., Jr. 1976. Mapping relic drainages and site locations: an assessment of the use of remote sensing in the Village Creek Basin. In Klinger 1976a, pp. 311–32.

Cowgill, G. L. 1975. A selection of samplers: comments on archaeo-statistics. In *Sampling in Archaeology*, pp. 258–74 (ed. J. W. Mueller). Tucson: University of Arizona Press.

Dancey, W. S. 1974. The archeological survey: a reorientation. *Man in the Northeast*. 8:98–112.

Daniels, S. G. H. 1972. Research design models. In *Models in Archaeology*, pp. 201–29 (ed. D. L. Clarke). London: Methuen.

DeBloois, E. I. 1975. The Elk Ridge Archeological Project: a test of random sampling in archeological surveying. *U.S.D.A. Forest Service, Intermountain Region, Archeological Report* 2.

Deetz, J. F. 1968. Hunters in archeological perspective. In *Man the Hunter*, pp. 281–5 (eds R. B. Lee and I. DeVore). Chicago: Aldine.

Dillehay, T. D. 1973. Small archeological site investigations for interpretation of site activities. *Bulletin of the Texas Archeological Society*. 44:169–77.

Dincauze, D. F. 1977. Second guessing: cost analysis of an intensive survey. In Conservation archaeology in the Northeast: towards a research orientation (ed. A. E. Spiess). *Coalition for Archaeology in Massachusetts, Occasional Publication* 1.

Doelle, W. H. 1976. Desert resources and Hohokam subsistence: the CONOCO Florence Project. *Arizona State Museum, Archaeological Series* 103.

Doelle, W. H. 1977. A multiple survey strategy for cultural resource management studies. In Schiffer and Gumerman 1977b, pp. 201–9.

Donaldson, B. R. 1975. An archeological sample of the White Mountain Planning Unit, Apache-Sitgreaves National Forest, Arizona. *USDA, Forest Service, Southwestern Region, Archeological Report* 6.

Donaldson, B. R. 1977. Lessons from the White Mountain Planning Unit: a small-sample survey design for large areas. In Archeology and National Forest land management planning, pp. 35–50. *USDA Forest Service, Southwestern Region, Archeological Report* 16.

Dunnell, R. C. and Dancey, W. S. n.d. Siteless surveys: a regional data collection strategy.

Ebert, J. I. and Hitchcock, R. K. 1977. The role of remote sensing. In Reher 1977, pp. 191–215.

Eidt, R. C. 1977. Detection and examination of anthrosols by phosphate analysis. *Science*. 197:1327–33.

Enloe, J. G. 1977. An evaluation of surface collection strategies in cultural resource survey. In Archeological reports (eds F. J. Broilo and D. E. Stuart). *University of New Mexico, Office of Contract Archeology, Cultural Resource Management Project Series* 2.

Epperson, T. W. 1977. Final report on archaeological inventory of the Challis Planning Unit, Bureau of Land Management. *Idaho State University, Museum of Natural History, Archaeological Reports* 11.

Euler, R. C. and Gumerman, G. J. (eds). 1977. Investigations of the Southwestern Anthropological Research Group: an experiment in archaeological cooperation. *Museum of Northern Arizona, Bulletin* 50.

Fehon, J. F. and Viscito, A. D. 1974. Archeological and historical inventory and preliminary field reconnaisance of Village Creek, Jackson and Lawrence counties, Arkansas. *Arkansas Archeological Survey, Research Report* 2.

Fish, P. R. 1976. Patterns of prehistoric site distribution in Effingham and Screven counties, Georgia. *University of Georgia, Laboratory of Archaeology, Series Report* 11.

Fish, P. R. n.d. Salvaging the survey: a case study in Georgia. *Journal of Field Archaeology* (in press, MS. 1977).

Flannery, K. V. (ed.). 1976a. *The Early Mesoamerican Village*. New York: Academic Press.

Flannery, K. V. 1976b. Sampling on the regional level – Introduction. In Flannery 1976a, pp. 131–6.

Flannery, K. V. 1976c. The trouble with regional sampling. In Flannery 1976a, pp. 159–60.

Fox, A. A. and Hester, T. R. 1976. An archaeological survey of Coleto Creek, Victoria and Goliad counties, Texas. *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report* 18.

Fuller, S. L., Rogge, A. E. and Gregonis, L. M. 1976. Orme alternatives: the archaeological resources of Roosevelt Lake and Horseshoe Reservoir. *Arizona State Museum, Archaeological Series* 98.

Gerstle, A., Kelly, T. and Assad, C. 1977. The Fort Sam Houston Project: an archaeological and historical assessment. *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report* 40.

Glassow, M. A. 1968. A maximum dispersion model for the random sampling of archaeological sites. Paper read at the 33rd Annual Meeting of the Society for American Archaeology, Santa Fe.

Glassow, M. A. 1977a. *An Archaeological Overview of the Northern Channel Islands, California, including Santa Barbara Island.* Department of Anthropology, University of California, Santa Barbara.

Glassow, M. A. 1977b. *The Evaluation of the Significance of Two Archaeological Sites, SBa-19 and SBA-1213, in Montecito, California.* Department of Anthropology, University of California, Santa Barbara.

Goodyear, A. C. 1975. Hecla II and III; an interpretive study of archaeological remains from the Lakeshore Project, Papago Reservation, south-central Arizona. *Arizona State University, Department of Anthropology, Research Paper* 9.

Goodyear, A. C. 1977. Regional model building in the contract framework: the Hecla projects of southern Arizona. In Schiffer and Gumerman 1977b, pp. 413–26.

Goodyear, A. C., Raab, L. M. and Klinger, T. C. 1978. The status of archaeological research design in cultural resource management. In Contributions to archaeological method and theory (ed. M. B. Schiffer), *American Antiquity*. 43.

Grady, M. A. 1975. Archaeological survey and the future of cultural resource management. Paper read at the 40th Annual Meeting of the Society for American Archaeology, Dallas, Texas.

Greenwood, N. H. and White, C. W. 1970. Mogollon ritual: a spatial configuration of a non-village pattern. *Archaeology*. 23:298–301.

Gumerman, G. J. (ed.). 1971. The distribution of prehistoric population aggregates. *Prescott College, Anthropological Reports* 1.

Gunn, J. D., Ivey, J. E. and Kelly, T. C. 1977. Research design and field procedures. In An archaeological survey of the Radium Springs area, Southern New Mexico, pp. 4–9 (ed. T. R. Hester). *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report* 26.

Hanson, G. T. n.d. A proposal to the National Park Service for: The completion of archeological survey, testing, and assessment in the proposed R. B. Russell Reservoir and associated impact areas in South Carolina and Georgia. Manuscript on deposit, Institute of Archeology and Anthropology, University of South Carolina, Columbia.

Harp, E. Jr. (ed.). 1975. *Photography in Archaeological Research.* Albuquerque: University of New Mexico Press.

Henderson, M. 1977. An archeological survey of the Amarillo timber sale, El Rito district, Carson National Forest. Manuscript, USDA Forest Service, Southwestern Region, Albuquerque.

Hester, T. R. (ed.) 1977a. An archaeological survey of the Radium Springs area, southern New Mexico. *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report* 26.

Hester, T. R. (assembler). 1977b. A preliminary archaeological and historical assessment of the proposed Tenneco pipeline: Hidalgo to Victoria counties, Texas. *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report.*

Hester, T. R., Heizer, R. F. and Graham, J. A. 1975. *Field Methods in Archaeology*. Palo Alto: Mayfield Press.

Hole, F. and Heizer, R. F. 1973. *An Introduction to Prehistoric Archeology* (Third Edition). New York: Holt, Rinehart and Winston.

House, J. H. 1975a. Prehistoric lithic resource utilization in the Cache Basin: Crowley's Ridge chert and quartzite and Pitkin chert. In Schiffer and House 1975, pp. 81–91.

House, J. H. 1975b. The Cache River Archeological Project: survey methods and contract archeology. *Southeastern Archaeological Conference Bulletin.* 18:98–107.

House, J. H. 1975c. The testing program. In Schiffer and House 1975, pp. 121–9.

House, J. H. and Ballenger, D. L. 1976. An archeological survey of the Interstate 77 route in the South Carolina Piedmont. *University of South Carolina, Institute of Archeology and Anthropology, Research Manuscript Series* 104.

House, J. H. and Schiffer, M. B. 1975. Archeological survey in the Cache River basin. In Schiffer and House 1975, pp. 37–53.

Jackson, T. L. 1976. Report of the Middle Eel Planning Unit Archaeological Survey. Manuscript, California State College, Sonoma.

Jelks, E. B. 1975. *The Use and Misuse of Random Sampling in Archeology*. Normal, Illinois: Jett Publishing Company.

Johnson, G. 1977. Aspects of regional analysis in archaeology. In *Annual Review of Anthropology, Volume 6, 1977*, pp. 479–508 (ed. B. J. Siegel). Palo Alto, Calif.: Annual Reviews.

Judge, W. J. 1973. *PaleoIndian Occupation of the Central Rio Grande Valley in New Mexico.* University of New Mexico Press, Albuquerque.

Judge, W. J., Ebert, J. I. and Hitchcock, R. K. 1975. Sampling in regional archaeological survey. In *Sampling in Archaeology*, pp. 82–123 (ed. J. W. Mueller). Tucson: University of Arizona Press.

Kelly, T. C. and Hester, T. R. n.d. Archaeological test excavations at Site 41 BX 300, Bexar county, south central Texas. *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report* (in press, MS. 1977).

King, T. F. 1975. *Cultural Resource Law and the Contract Archaeologist: Methods of Evaluation and Reporting*. Archaeological Resource Management Service, New York Archaeological Council, Buffalo and Albany.

King, T. F., Moratto, M. J. and Leonard III, N. N. 1973. *Recommended Procedures for Archaeological Impact Evaluation*. Society for California Archaeology and UCLA Archaeological Survey.

Klinger, T. C. (assembler). 1976a. Village Creek: an explicitly regional approach to the study of cultural resources. Draft report, Arkansas Archeological Survey, Fayetteville.

Klinger, T. C. 1976b. The problem of site definition in cultural resource management. *Arkansas Academy of Science, Proceedings*. 30:54–6.

Klinger, T. C. (assembler) 1977a. New Hope: an archeological assessment of a proposed strip mine tract in the gulf Coastal Plain of southwest Arkansas. Draft report, Arkansas Archeological Survey, Fayetteville.

Klinger, T. C. 1977b. 1977 New Hope research design. In Klinger 1977a.

Klinger, T. C. 1977c. Results of the 1977 sample survey. In Klinger 1977a.

Klinger, T. C. and Medlin, S. 1976. Budget analysis – cost accounting. In Klinger 1976a.

Klinger, T. C. and Medlin, S. 1977. Budget analysis – cost accounting. In Klinger 1977a.

Lovis, W. A. 1976. Quarter sections and forests: an example of probability sampling in the northeastern woodlands. *American Antiquity*. 41:364–72.

Lyons, T. R. (assembler). 1976. Remote sensing experiments in cultural resource studies: non-destructive methods of archeological exploration, survey, and analysis. *National Park Service, Chaco Center, Report* 1.

Lyons, T. R. and Hitchcock, R. K. (ed). 1977. Aerial remote sensing techniques in archeology. *National Park Service, Chaco Center, Report* 2.

McEachern, J. M. and Grady, M. A. 1977. New Melones cave inventory and evaluation study. preliminary report: archaeological caves. *Southern Methodist University, Archaeology Research Program, Research Reports* 103.

McGimsey III, C. R. and Davis, H. A. (eds). 1977. *The Management of Archeological Resources: the Airlie House Report*. Special Publication of the Society for American Archaeology, Washington, D.C.

McManamon, F. P. 1977. Site identification in the Northeast. In Conservation archaeology in the Northeast: towards a research orientation (ed. A. E. Spiess). *Coalition for Archaeology in Massachusetts, Occasional Publication 1*.

McMillan, B., Grady, M., Lipe, W., Anderson, A., Davis, H., Pierson, L. and Weide, M. 1977. Cultural resource management. In McGimsey and Davis 1977, pp. 25–63.

Matson, R. G. and Lipe, W. D. 1975. Regional sampling: a case study of Cedar Mesa, Utah. In *Sampling in Archaeology*, pp. 124–43 (ed. J. W. Mueller). Tucson: University of Arizona Press.

Mayer-Oakes, W. J. and Nash, R. J. 1967. Archaeological research design – a critique. Unpublished manuscript.

Moratto, M. J. 1976. New Melones Archaeological Project – Stanislaus River, Calaveras and Tuolumne counties, California: Phase VI, Part 3, archaeological inventory. *San Francisco State University, Archaeological Research Laboratory, Conservation Archaeology Papers* 3.

Morenon, E. P., Henderson, M. and Nielson, J. 1976. The development of conservation techniques and a land use study conducted near Ranchos de Taos, New Mexico. Manuscript, Fort Burgwin Research Center of Southern Methodist University.

Moseley, M. E. and Mackey, C. J. 1972. Peruvian settlement pattern studies and small site methodology. *American Antiquity*. 37:67–81.

Mueller, J. W. 1974. The use of sampling in archaeological survey. *Society for American Archaeology, Memoirs* 28.

Mueller, J. W. (ed.). 1975a. *Sampling in Archaeology*. Tucson: University of Arizona Press.

Mueller, J. W. 1975b. Archaeological research as cluster sampling. In Mueller 1975a, pp. 33–41.

Mueller, J. W. 1978. A reply to Plog and Thomas. In Contributions to archaeological method and theory (ed. M. B. Schiffer). *American Antiquity*. 43.

Nunley, P. and Hester, T. R. 1975. An assessment of archaeological resources in portions of Starr county, Texas. *University of Texas at San Antonio, Center for Archaeological Research, Archaeological Survey Report* 7.

Peebles, C. S., Sallade, J., Arnold, J., Braun, D. and Steponaitis, V. 1976. *The River Raisin Archaeological Survey, Season 1, 1975: a preliminary report*. Museum of Anthropology, University of Michigan, Ann Arbor.

Perlman, S. M. 1977. The Sandy Point site: an analysis of materials excavated to fulfill environmental impact statement requirements. Manuscript, Department of Anthropology, University of Maine, Portland-Gorham.

Peters, C. R. 1970. Introductory topics in probability sampling theory for archaeology. *Anthropology UCLA*. 2:33–50.

Plog, F. T. 1968. Archaeological surveys: a new perspective. M.A. thesis, University of Chicago.

Plog, F. T. 1974a. *The Study of Prehistoric Change*. New York: Academic Press.

Plog, F. T. 1974b. Settlement patterns and social history. In *Frontiers of Anthropology*, pp. 68–92 (ed. M. Leaf). New York: Van Nostrand.

Plog, F. n.d.a. Sampling strategies in the White Mountain Planning Unit. *USDA Forest Service, Southwestern Region, Archeological Reports* (in press, MS. 1977).

Plog, F. (ed.). n.d.b. The Little Colorado planning unit, eastern sector: an analytical approach to cultural resource management. *USDA Forest Service, Southwestern Region, Archeological Reports* (in press, MS. 1977).

Plog, F. and Wood, J. S. 1977. The research potential of multiple-use studies. In Archeology and National Forest land management planning, pp. 51–7. *USDA Forest Service, Southwestern Region, Archeological Reports* 16.

Plog, F., Weide, M. and Stewart, M. 1977. Research design in the SUNY-Binghamton contract program. In Schiffer and Gumerman 1977b, pp. 107–20.

Plog, S. 1976a. Relative efficiencies of sampling techniques for archeological surveys. In Flannery 1976a, pp. 136–58.

Plog, S. 1976b. Review II. In Fuller, Rogge, and Gregonis 1976, pp. 277–81.

Plog, S. 1978. Sampling in archaeological surveys: a critique. In Contributions to archaeological method and theory (ed. M. B. Schiffer). *American Antiquity*. 43.

Plog, S., Plog, F. and Wait, W. 1978. Decision-making in modern surveys. In *Advances in Archaeological Method and Theory, Volume 1, 1978* (ed. M. B. Schiffer). New York: Academic Press.

Portnoy, A. W. (ed.). 1978. *Scholars as Managers*. National Park Service, Interagency Services, Washington, D.C.

Price, J. E., Price, C. R., Cottier, J., Harris, S. and House, J. 1975. *An Assessment of the Cultural Resources of the Little Black Watershed.* University of Missouri-Columbia.

Price, J. E., Price, C. R. and Harris, S. E. 1976. *An Assessment of the Cultural Resources of the Fourche Creek Watershed.* University of Missouri-Columbia.

Raab, L. M. 1977. An archeological sample survey of the Caddo Planning Unit, Ouachita National Forest, Arkansas. In Archeology and national forest land management planning, pp. 22–34. *USDA Forest Service, Southwestern Region, Archeological Report* 16.

Ragir, S. 1967. A review of techniques for archaeological sampling. In *A Guide to Field Methods in Archaeology*, pp. 181–97 (by R. F. Heizer and J. A. Graham). Palo Alto: National Press.

Read, D. W. 1975. Regional sampling. In Mueller 1975a, pp. 45–60.

Read, D. W. 1977. The use and efficacy of random samples in regional surveys. In Chevelon archeological research reports: I, pp. 19–26 (eds F. Plog, J. N. Hill and D. W. Read). *UCLA Archaeological Survey, Monograph* 2.

Redman, C. L. 1974. Archeological sampling strategies. *Addison-Wesley Module in Anthropology* 55.

Redman, C. L. and Watson, P. J. 1970. Systematic intensive surface collection. *American Antiquity.* 35:279–91.

Reher, C. A. (ed.) 1977. *Settlement and Subsistence along the Lower Chaco River: the CGP Survey.* Albuquerque: University of New Mexico Press.

Reid, J., Schiffer, M. B. and Neff, J. M. 1975. Archaeological considerations of intrasite sampling. In Mueller 1975a, pp. 209–24.

Richner, J. J. and Lee, R. 1977. Archaeological survey at Tennessee Colony Lake: 1975. *Southern Methodist University, Archaeology Research Program, Research Reports* 104.

Roberts, M. 1977. *Guidelines for the Management of Archaeological Properties that may be Impacted by Water Pollution Control Programs.* Institute for Conservation Archaeology, Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, Massachusetts.

Rodgers, J. B. 1974. An archaeological survey of the Cave Buttes dam alternative site and reservoir, Arizona. *Arizona State University, Anthropological Research Paper* 8.

Rogge, A. E. and Fuller, S. L. 1977. Probabilistic survey sampling: making parameter estimates. In M. B. Schiffer and G. J. Gumerman 1977b, pp. 227–38.

Ruppé, R. J. 1966. The archeological survey: a defense. *American Antiquity.* 31:313–33.

Schiffer, M. B. 1975. Archaeological research and contract archeology. In Schiffer and House 1975, pp. 1–7.

Schiffer, M. B. 1976. *Behavioral Archeology.* New York, Academic Press.

Schiffer, M. B. 1977. Toward a unified science of the cultural past. In South 1977b, pp. 13–40.

Schiffer, M. B. 1978. Research design considerations for the mega-survey: a first approximation. In Portnoy 1978.

Schiffer, M. B. and Gumerman, G. J. 1977a. Cultural resource management. In Schiffer and Gumerman 1977b, pp. 1–17.

Schiffer, M. B. and Gumerman, G. J. (eds). 1977b. *Conservation Archaeology: a Guide for Cultural Resource Management Studies.* New York: Academic Press.

Schiffer, M. B. and Gumerman, G. J. 1977c. Acquisition of survey data. In Schiffer and Gumerman 1977b, pp. 183–190.

Schiffer, M. B. and House, J. H. (assemblers). 1975. The Cache River Archeological Project: an experiment in contract archeology. *Arkansas Archeological Survey, Research Series* 8.

Schiffer, M. B. and House, J. H. 1977a. Archaeological research and cultural resource management: the Cache Project. *Current Anthropology*. 18:43–68.

Schiffer, M. B. and House, J. H. 1977b. The Cache Project survey design. In Schiffer and Gumerman 1977b, pp. 191–200.

Schiffer, M. B. and Rathje, W. L. 1973. Efficient exploitation of the archeological record: penetrating problems. In *Research and Theory in Current Archeology*, pp. 169–79 (ed. C. L. Redman). New York: Wiley-Interscience.

Schoenwetter, J., Gaines, S. W. and Weaver, D. E., Jr. 1973. Definition and preliminary study of the Midvale site. *Arizona State University, Department of Anthropology, Research Paper* 6.

Skinner, S. A. and Gallagher, J. 1974. An evaluation of the archaeological resources at Lake Whitney, Texas. *Southern Methodist University, Contributions in Anthropology* 14.

South, S. 1977a. *Method and Theory in Historical Archeology*. New York: Academic Press.

South, S. (ed.). 1977b. *Research Strategies in Historical Archeology*. New York: Academic Press.

Struever, S. 1971. Comments on archaeological data requirements and research strategy. *American Antiquity*. 36:9–19.

Sullivan, A. P. 1978. Inference and evidence in archaeology: a discussion of the conceptual problems. In *Advances in Archaeological Method and Theory, Volume 1, 1978* (ed. M. B. Schiffer). New York: Academic Press.

Sullivan, A. P. and Schiffer, M. B. 1977. A critical examination of SARG. In Euler and Gumerman 1977, pp. 169–77.

Synenki, A. T. 1977. Explaining the relationship between surface and subsurface remains: a multivariate approach. M. A. thesis, Department of Anthropology, Southern Illinois University, Carbondale.

Talmage, V. and Chesler, O. 1977. *The Importance of Small, Surface, and Disturbed Sites as Sources of Significant Archaeological Data*. Office of Archeology and Historic Preservation, National Park Service, Washington, D.C.

Thomas, D. H. 1975. Nonsite sampling in archaeology: up the creek without a site? In Mueller 1975a, pp. 61–81.

Thomas, D. H. 1978. The awful truth about statistics in archaeology. In Contributions to archaeological method and theory (ed. M. B. Schiffer). *American Antiquity*. 43.

Tolstoy, P. and Fish S. K. 1975. Surface and subsurface evidence for community size at Coapexco, Mexico. *Journal of Field Archaeology*. 2:97–104.

True, D. L. and Matson, R. G. 1974. Random sampling procedures in archaeological surveying: an evaluation. In Readings in archaeological method and theory, pp. 83–98 (ed. R. Kautz). *Center for Archaeological Research at Davis, Publication Number* 4.

Vivian, R. G., Anderson, K., Davis, H., Edwards, R., Schiffer, M. B. and South, S. 1977. Guidelines for the preparation and evaluation of archeological reports with particular reference to cultural resource management studies. In McGimsey and Davis 1977, pp. 64–77.

Vogt, E. Z. (ed.). 1974. *Aerial Photography in Anthropological Field Research.* Cambridge: Harvard University Press.

Wait, W. n.d. *Archaeological Survey of Star Lake, New Mexico.* Carbondale: Southern Illinois University Press (in press, MS, 1977).

Williams, K. R. 1976. A preliminary assessment of techniques applied in the FAI-255 survey. Paper read at the 41st Annual Meeting of the Society for American Archaeology, St Louis.

Wood, W. R. and Johnson, D. L. 1978. A survey of disturbance processes in archaeological site formation. In *Advances in Archaeological Method and Theory, Volume 1, 1978* (ed. M. B. Schiffer). New York: Academic Press.

Zubrow, E. B. W. 1975. *Prehistoric Carrying Capacity: a Model.* Menlo Park, California: Cummings.

Abstract

Schiffer, Michael B., Sullivan, Alan P. and Klinger, Timothy C.

The design of archaeological surveys

Archaeological survey design is viewed as a problem in choosing techniques for site and artefact discovery that are most cost-effective given the particular archaeological and environmental characteristics of the study area. Uncontrollable factors of the study area discussed are abundance, clustering, obtrusiveness of archaeological materials, and visibility and accessibility. Both purposive and probabilistic techniques for varying discovery probabilities are examined within the framework of recovery theory. In addition, other considerations involved in survey design are reviewed, including field crews, site definition, recording procedures, surface collecting and testing. Finally, a three-stage survey programme is outlined, wherein stress is laid on acquiring the knowledge needed for making decisions about survey techniques.